New York University Tandon School of Engineering
Department of Computer Science & Engineering

CS3224 Spring 2020
Operating Systems Design and Implementation
Professor Sandoval

Contact:
Email: gustavo.sandoval@nyu.edu
My background is here.

Jay Street Building, Office 846
Office hours: tbd
  ▪ If these times don’t work for you, email me and we can set up a time to meet.

Student Assistants & Office Hours:

Course Pre-requisites

CS-UY 2214 (Computer Architecture and Organization)
CS-UY 2134 (Data Structures and Algorithms)
Strong Programming in C or C++. (You will have a very hard time, and are at risk of failing the class if you haven’t programmed in C or C++ before)

Course Description

This course is an introduction to operating system design and implementation. We study operating systems because they are examples of mature and elegant solutions to a difficult design problem: how to safely and efficiently share system resources and provide abstractions useful to applications.

For the processor, memory, and disks, we discuss how the operating system allocates each resource and explore the design and implementation of related abstractions.

We also establish techniques for testing and improving system performance and introduce the idea of hardware virtualization. Programming assignments provide hands-on experience with implementing core operating system components in a realistic development environment. We will examine in detail the design and
implementation of a UNIX-like operating system, and cover general operating systems concepts, such as processes, threads, device drivers, filesystems, scheduling, and concurrency.

Readings

Textbooks:

- Arpaci-Dusseau, R and Arpaci-Dusseau A. **Operating Systems Three Easy Pieces.** Available [online](http://free) for free.
- Andrew S. Tannenbaum, **Modern Operating Systems.** Available on NYU Classes.

Useful references:


Course requirements

- Attendance will not be taken, but it is highly recommended and it will help with your participation.
- Assignments must be received by midnight on the day they are due. Late homework will not be accepted.

Cooperation Policy

You will work individually on every assignment. You may discuss solutions with your classmates but stop short or sharing your code with them.

Academic Honesty

All work submitted in this course must be your own. Cheating and plagiarism will not be tolerated. If you have any questions about a specific case, *please ask me.*

NYU Poly’s Policy on Academic Misconduct: [http://engineering.nyu.edu/academics/code-of-conduct/academic-misconduct](http://engineering.nyu.edu/academics/code-of-conduct/academic-misconduct)
Course schedule *(Tentative)*

The course schedule is tentative, it’s likely to change as the weeks go on.
In the following, OSTEP stands for Operating Systems Three Easy Pieces, MOS stands for “Modern Operating Systems”, xv6 stands for “xv6: A simple, Unix-like teaching operating system”

<table>
<thead>
<tr>
<th>Week</th>
<th>Theme</th>
<th>Topic</th>
<th>Assignment</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Jan 28</td>
<td><strong>Introductory Topics</strong></td>
<td>Course Information. OS Intro.</td>
<td>HW1 out - intro</td>
<td>OSTEP 1 xv6 0-1</td>
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<tr>
<td>1 – Jan 30</td>
<td></td>
<td>C Programming Review</td>
<td></td>
<td>MOS 1 &amp; xv6 0-1</td>
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<tr>
<td>2 – Feb 4</td>
<td></td>
<td>OS Overview</td>
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<td>MOS 1 &amp; xv6 0-1</td>
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<tr>
<td>2 – Feb 6</td>
<td></td>
<td>PC Hardware &amp; Assembly Language</td>
<td>HW2 out-Assembly</td>
<td>MOS 1 &amp; xv6 0-1</td>
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<td>3 – Feb 11</td>
<td></td>
<td>PC Hardware &amp; Assembly Language</td>
<td></td>
<td>MOS 1 &amp; xv6 0-1</td>
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<td>3 – Feb 13</td>
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<td>The Boot Process</td>
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<td>xv6 Appendix B</td>
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<td>4 – Feb 18</td>
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<td>System Call Interface</td>
<td>HW3 out – System Calls</td>
<td>xv6 Appendix B</td>
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<tr>
<td>4 – Feb 20</td>
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<td>Processes</td>
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<td>OSTEP 4, MOS 2 &amp; xv6 5</td>
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<tr>
<td>5 – Feb 25</td>
<td></td>
<td>Process API</td>
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<td>OSTEP 5, MOS 2 &amp; xv6 5</td>
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<td>5 – Feb 27</td>
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<td>Scheduling Algorithms</td>
<td>Midterm Review</td>
<td>OSTEP 7, MOS 2 &amp; xv6 5</td>
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<td>6 – Mar 3</td>
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<td>Midterm Review</td>
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<td>6 – Mar 5</td>
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<td><strong>Midterm 1</strong></td>
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<td>7 – Mar 10</td>
<td><strong>Memory Virtualization</strong></td>
<td>Memory Management</td>
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<td>MOS 3.3-3.5 &amp; xv6 2</td>
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<td>7 – Mar 12</td>
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<td>Memory Management</td>
<td>HW5 out – Memory Management</td>
<td>MOS 3.3-3.5 &amp; xv6 2</td>
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<td>8 – Mar 17</td>
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<td><strong>Spring Break</strong></td>
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<td>8 – Mar 19</td>
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<td>Date</td>
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<td>9 – Mar 24</td>
<td>Virtual Memory</td>
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<td>MOS 3.3-3.5 &amp; xv6 2</td>
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<td>9 – Mar 26</td>
<td>Virtual Memory</td>
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<td>MOS 3.3-3.5 &amp; xv6 2</td>
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<td>10 – Mar 31</td>
<td>Virtual Memory</td>
<td>Midterm Review</td>
<td>MOS 3.3-3.5 &amp; xv6 2</td>
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<td>10 – Apr 2</td>
<td>Concurrency</td>
<td>Threads</td>
<td>MOS 3.1-3.2 &amp; xv6 2</td>
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<td>April 3 Last day to withdraw from a class</td>
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<td>11 – Apr 7</td>
<td>Concurrency</td>
<td>HW4 out - Concurrency</td>
<td>MOS 2.3 – 2.5</td>
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<td>11 – Apr 9</td>
<td>Concurrency</td>
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<td>MOS 2.3 – 2.5</td>
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<td>12 – Apr 14</td>
<td>Midterm Review</td>
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<td>12 – Apr 16</td>
<td>Midterm 2</td>
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<td>13 – Apr 21</td>
<td>Persistence</td>
<td>Storage &amp; Filesystems</td>
<td>MOS 4.1-4.4 &amp; xv6 6</td>
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<td>13 – Apr 23</td>
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<td>Storage &amp; Filesystems</td>
<td>MOS 4.1-4.4 &amp; xv6 6</td>
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<td>14 – Apr 28</td>
<td>Device Drivers, Interrupts,</td>
<td>Extra Credit out</td>
<td>MOS 5 &amp; xv6 3</td>
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<td>and I/O</td>
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<td>14 – Apr 30</td>
<td>Security</td>
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<td>MOS 9</td>
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<td>15 – May 5</td>
<td>Advanced Topics</td>
<td>Virtualization</td>
<td>MOS 7</td>
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<td>15 – May 7</td>
<td>Final Exam Review</td>
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<td>May 13 - 19</td>
<td><strong>Final Exam</strong> (Final date</td>
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Grading
Grading will be based on the following weights.

20% Homework (Programming Projects)
25% Midterm 1
25% Midterm 2
25% Final
5% Participation

Grading Schema:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A</td>
<td>92</td>
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<tr>
<td>A-</td>
<td>89</td>
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<tr>
<td>B+</td>
<td>86</td>
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<tr>
<td>B</td>
<td>83</td>
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<tr>
<td>B-</td>
<td>80</td>
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<td>C+</td>
<td>75</td>
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<tr>
<td>C</td>
<td>70</td>
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<tr>
<td>C-</td>
<td>65</td>
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<td>D+</td>
<td>60</td>
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<tr>
<td>D</td>
<td>51</td>
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<td>F</td>
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Other Grading notes:

Please take the following into consideration during and after the semester and save yourself one or many emails.

1) **I must grade every student EXACTLY the same way.** To this end, I cannot give you special consideration as a result of your academic status (probation or otherwise), scholarships, work status, family situation, visa status, race, color, creed, religious beliefs, past alien abductions, current moon cycle, location of the sun in the sky or anything other than your academic performance. **Your grade must be based on your academic performance in my class.**
2) **I cannot change your grade simply because you ask me to.** Your grade is calculated based on your performance from the first day of class to moment you turn in the final exam.

3) **I will not give you additional work.** Please remember that I must treat all students the same, so if I give you additional work, I would have to give it to the entire class. This is unfair to the students who complete their work on time.

4) **Your grade is a measure of your performance in my class.** If you receive an “F” it is because you have demonstrated that you do not understand the material in the course; if you receive an “A” it is because you have demonstrated that you fully understand the material covered in the course. Other grades are assigned accordingly.

**Moses Center Statement of Disability**

If you are student with a disability who is requesting accommodations, please contact New York University’s Moses Center for Students with Disabilities (CSD) at 212-998-4980 or mosescsd@nyu.edu. You must be registered with CSD to receive accommodations. Information about the Moses Center can be found at www.nyu.edu/csd. The Moses Center is located at 726 Broadway on the 3rd floor.

**NYU School of Engineering Policies and Procedures on Academic Misconduct – complete Student Code of Conduct [here](#)**

A. **Introduction:** The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School’s rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School’s Policy on Academic Misconduct.

B. **Definition:** Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other
students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:

1. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person’s work during an exam; submitting work prepared in advance for an in-class examination; having someone take an exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.
2. Fabrication: including but not limited to, falsifying experimental data and/or citations.
3. Plagiarism: intentionally or knowingly representing the words or ideas of another as one’s own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
4. Unauthorized collaboration: working together on work meant to be done individually.
5. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission has been received from the course instructor(s) or research adviser involved.
6. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.

NYU School of Engineering Policies and Procedures on Excused Absences — complete policy [here](#)

A. Introduction: An absence can be excused if you have missed no more than 10 days of school. If an illness or special circumstance has caused you to miss more than two weeks of school, please refer to the section labeled Medical Leave of Absence.

B. Students may request special accommodations for an absence to be excused in the following cases:

1. Medical reasons
2. Death in immediate family
3. Personal qualified emergencies (documentation must be provided)
4. Religious Expression or Practice
Deanna Rayment, deanna.rayment@nyu.edu, is the Coordinator of Student Advocacy, Compliance and Student Affairs and handles excused absences. She is located in 5 MTC, LC240C and can assist you should it become necessary.

NYU School of Engineering Academic Calendar – complete list here.

The last day of the final exam period is _May 19_. Final exam dates for undergraduate courses will not be determined until later in the semester.

Also, please pay attention to notable dates such as Add/Drop, Withdrawal, etc. For confirmation of dates or further information, please contact Susana: sgarcia@nyu.edu